

CLAIMS

What is claimed is:

1. An apparatus comprising:
a charge pump circuit comprising:
 - 5 a first current source and second current source;
a first differential pair of switches coupled to the first current source, the first differential pair of switches comprising a first switch controlled by a first voltage signal and a second switch controlled by a second voltage signal, the second voltage signal being inversed with respect to the first voltage signal;
 - 10 a second differential pair of switches coupled to the second current source, the second differential pair of switches comprising a third switch controlled by a third voltage signal and a fourth switch controlled by a fourth voltage signal, the fourth voltage signal being inversed with respect to the third voltage signal, wherein the first switch and the third switch are coupled in series between the first current source and the second current source, an output terminal is
 - 15 disposed between the first and third switches, the second switch and the fourth switch are coupled in series between the first current source and the second current source;
a transient reducing circuit comprising:
 - a third current source and a fourth current source;
 - a fifth switch and a sixth switch coupled in series between the third current
 - 20 source and the fourth current source, the fifth switch controlled by the fourth voltage signal and the sixth switch controlled by the second voltage signal; and
an input node between the fifth switch and the sixth switch, the input node coupled to a node between the second switch and the fourth switch.
- 25 2. The apparatus of Claim 1, further comprising:
a loop filter coupled to the output terminal;
a common mode feedback circuit coupled to the output terminal;
3. The apparatus of Claim 2, further comprising:
30 a first variable current source coupled to the first differential pair of switches;

a second variable current source coupled to the second differential pair of switches;
a third variable current source coupled to the third current source; and
a fourth variable current source coupled to the fourth current source, wherein the fifth
and sixth switches are coupled in series between the third variable current source and the fourth
5 variable current source;

wherein the common mode feedback circuit is coupled to the first variable current
source, the second variable current source, the third variable current source, and the fourth
variable current source.

10 4. The apparatus of Claim 3, wherein the magnitude of the current provided by each of the
first variable current source, the second variable current source, the third variable current
source, and the fourth variable current source is less than the magnitude of the current provided
by each of the first current source, the second current source, the third current source and fourth
current source.

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5. The apparatus of Claim 1, further comprising:

a fifth current source and sixth current source;

a third differential pair of switches coupled to the fifth current source, the third
differential pair of switches comprising a seventh switch controlled by the third voltage signal
20 and an eighth switch controlled by the fourth voltage signal;

a fourth differential pair of switches coupled to the sixth current source, the fourth
differential pair of switches comprising a ninth switch controlled by the first voltage signal and
a tenth switch controlled by the second voltage signal, wherein the seventh switch and the ninth
switch are coupled in series between the fifth current source and the sixth current source, a
25 second output terminal is disposed between the seventh switch and the ninth switch, the eighth
switch and the tenth switch are coupled in series between the fifth current source and the sixth
current source;

a second transient reducing circuit comprising:

a seventh current source and an eighth current source;

- an eleventh switch and a twelfth switch coupled in series between the seventh current source and the eighth current source, the seventh switch controlled by the second voltage signal and the twelfth switch controlled by the fourth voltage signal; and
a second input node between the eleventh switch and the twelfth switch, the second input node coupled to a node between the eighth switch and the tenth switch.
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6. The apparatus of Claim 5, further comprising:
a first loop filter coupled to the output terminal between the first switch and the third switch;
10 a second loop filter coupled to the second output terminal between the seventh switch and the ninth switch;
a common mode feedback circuit coupled to the first loop filter and the second loop filter.
- 15 7. A charge pump comprising:
a first current source, a second current source, a third current source, and a fourth current source;
a first switch and a second switch coupled in series between the first current source and the second current source, an output terminal disposed between the first switch and the second switch;
20 a first switchable current path from the third current source to the second current source that is open when the first switch is active;
a second switchable current path from the first current source to the fourth current source that is open when the second switch is active; and
25 a third switchable current path from the third current source to the fourth current source when neither the first switch nor the second switch are active.
8. The charge pump of Claim 7, further comprising:
a first variable current source coupled in parallel with the first current source;
30 a second variable current source coupled in parallel with the second current source;

a third variable current source coupled in parallel with the third current source;
a fourth variable current source coupled in parallel with the fourth current source;
wherein the first variable current source, the second variable current source, the third
variable current source, and the fourth variable current source are coupled to receive a common
5 mode feedback control signal.

9. The charge pump of Claim 8, wherein the magnitude of the current provided by each of
the first variable current source, the second variable current source, the third variable current
source, and the fourth variable current source is less than the magnitude of the current provided
10 by each of the first current source, the second current source, the third current source and fourth
current source.

10. The charge pump of Claim 8, further comprising:
a fifth current source, a sixth current source, a seventh current source, and a eighth
15 current source;
a fifth switch and a sixth switch coupled in series between the fifth current source and
the sixth current source, a second output terminal disposed between the fifth switch and the
sixth switch;
a fourth switchable current path from the seventh current source to the sixth current
20 source that is open when the fifth switch is active;
a sixth switchable current path from the fifth current source to the eighth current source
that is open when the sixth switch is active; and
a seventh switchable current path from the seventh current source to the eighth current
source when neither the fifth switch nor the sixth switch are active.

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11. A method of controlling a charge pump, the method comprising:
providing a current along a first current path from a first current source to a second
current source while providing a pull up current to an output terminal;
providing a current along a second current path from a third current source to a fourth
30 current source while providing a pull down current to the output terminal; and

providing a current along a third current path from the first current source to the fourth current source while neither a pull up current nor a pull down current are provided to the output terminal.

5 12. The method of Claim 11, further comprising:
 providing the pull up current from the third current source to the output terminal; and
 providing the pull down current from the second current source to the output terminal.

10 13. The method of Claim 11, wherein:
 providing a current along a first current path comprises providing a portion of the
 current with a constant magnitude and providing the remaining portion of the current with a
 variable current;

 providing a current along a second current path comprises providing a portion of the
 current with a constant magnitude and providing the remaining portion of the current with a
15 variable current;

 providing a current along a third current path comprises providing a portion of the
 current with a constant magnitude and providing the remaining portion of the current with a
 variable current.

20 14. The method of Claim 13, further comprising controlling the variable current with a
 common mode feedback circuit coupled to the output terminal.

 15. The method of Claim 14, wherein the magnitude of the variable current is less than the
 magnitude of the portion of the current with a constant magnitude for any of the currents along
25 the first current path, the second current path and the third current path.

 16. The method of Claim 11, further comprising:
 providing a current along a fourth current path from a fifth current source to a sixth
 current source while providing a pull up current to a second output terminal;

providing a current along a fifth current path from a seventh current source to an eighth current source while providing a pull down current to the second output terminal; and

providing a current along a sixth current path from the fifth current source to the eighth current source while neither a pull up current nor a pull down current are provided to the

5 second output terminal.